On the 'bio-way' to sustainability: novel fermentation pathways to produce fuels and chemicals

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The search for novel technologies to generate renewable chemicals and fuels has attracted large attention in recent years, mainly because of the necessity to develop sustainable alternatives for fossil fuel based processes. The conversion of biomass and organic wastes by fermentation processes is of growing importance. Whereas in the past microbial conversions were limited to 'simple molecules' like bio-ethanol, methane (via anaerobic digestion) or hydrogen production, the application of microbial resource management paves the way towards the fermentative production of more complex and value added organic molecules, which can be used as a feedstock in chemical processes or as liquid fuel. In both cases, they can replace fossil fuels.

Microbial resource management aims to control and steer the capabilities of complex communities by operating the bioreactors in such a way to promote the development of a microbial community that accommodates the desired functional process. The application of molecular biology and the advent of culture-independent molecular techniques like high throughput DNA sequencing methods has caused a revolution in the capabilities to practice microbial resource management, opening the door to engineer communities with superior functions. Currently, bioreactors exploiting natural microbial communities for bioenergy production are commonly operated based on bulk parameters and empirical expert knowledge. The composition of the fermentation mixture in the bioreactor often remains a black box. The ability of current molecular and cell based methods to derive structure-function-relationships, that is, correlations between the microbial community structure and dynamics, and the reactor performance, are considered as key-criteria for the future development of biofuel production.

This paper will review the current state-of-the art in fermentation technology and will analyse the current trends in microbial resource management. Examples of applications will be presented with a focus on integration with process measurements to improve system performance.